

# Chinese American Oceanic and Atmospheric Association

COAA 2004



June 28-30, 2004  
Beijing, China

# MODIS On-orbit Spectral Calibration for the Reflective Solar Bands

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**Abstract** - The spectro-radiometric calibration assembly (SRCA) is one of the on-board calibrators (OBCs) in the Moderate Resolution Imaging Spectroradiometer (MODIS), a key instrument for NASA's Earth Observing System (EOS) Terra and Aqua missions. The Terra spacecraft was launched in December 1999 and Aqua in May 2002. Each MODIS makes observations in 36 spectral bands with wavelengths from 0.41 to 14.4 $\mu$ m. Bands 1-19 and 26 are the reflective solar bands (RSB) with wavelengths below 2.2 $\mu$ m and bands 20-25 and 27-36 are the thermal emissive bands (TEB) with wavelengths above 3.5 $\mu$ m. The SRCA was designed to perform instrument spatial (all bands) and spectral (RSB only) characterization on-orbit. Other calibrators, including a solar diffuser, a solar diffuser stability monitor, and a blackbody, are responsible for the sensor's radiometric calibration. When the SRCA is operated in spectral mode, it is capable of monitoring the RSB spectral response profile and center wavelengths. The pre-launch calibration references plus on-orbit wavelength self-calibration capability have enabled the SRCA to track the spectral characterization change throughout the MODIS instrument lifetime. This paper presents an overview of MODIS spectral calibration, from pre-launch to on-orbit. It describes the components of the SRCA when it is configured for the spectral calibration and its working principle. Results from Terra MODIS on-orbit characterization are provided. For most reflective solar bands, the on-orbit wavelength shifts during Terra's four and half year on-orbit operation are very small (less than 0.2nm). Only bands 8 and 9 have center wavelength shifts, including the initial shifts right after the instrument launch, of about 0.5nm.

## 1. Introduction

The Moderate Resolution Imaging Spectroradiometer (MODIS) Protoflight Model (PFM) was launched onboard NASA's Earth Observing System (EOS) Terra spacecraft on December 18, 1999. Its flight model 1 (FM1) on the EOS Aqua spacecraft was launched on May 4, 2002. Together they have provided nearly six and half years of calibrated data sets and produced many science products for various studies of the changes in the global environment<sup>1-3</sup>. With both Terra and Aqua MODIS continuously making on-orbit observations, the useful data sets will be extended further to help improve existing knowledge and better understand the changes of the Earth's atmospheric, oceanic, and terrestrial processes<sup>4-6</sup>.

The MODIS is the most comprehensive EOS sensor with a combination of many features designed to extend and enhance the data sets collected by its heritage sensors. Both Terra and Aqua MODIS went through extensive pre-launch radiometric, spatial, and spectral calibration and characterization activities. Each MODIS instrument has a design lifetime of five years. For such a complicated instrument, the system spatial, spectral, and radiometric characteristics need

to be constantly examined on-orbit. To accomplish this, the MODIS is equipped with a complete set of on-board calibrators, including a solar diffuser (SD), a solar diffuser stability monitor (SDSM), a v-grooved blackbody (BB), and a spectro-radiometric calibration assembly (SRCA).

It is known that the sensor's spectral response stability is directly related to its radiometric calibration accuracy and science data products quality. The spectral response stability, or its change, has a relatively large impact for the bands with narrow spectral bandwidths. The sensor's relative spectral response (RSR) is a critical parameter used in the radiometric calibration. It is also used in the radiometric transfer model involved in deriving other science products. Most of the Earth-observing sensors only perform spectral characterization during pre-launch calibration and characterization and assume the on-orbit change is small and negligible. The MODIS SRCA was designed to provide the long-term trending of its spectral response and the estimate of its impact on the radiometric calibration. The lessons and experience learned from MODIS instrument on-orbit characterization will also help the design and development of future Earth-observing sensors.